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TITLE OF THE INVENTION: LIQUID CRYSTAL DISPLAY DEVICE AND FABRICATING METHOD THEREOF AND METHOD OF REPAIRING PIXEL USING THE SAME

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SPECIFICATION

【TITLE OF INVENTION】

LIQUID CRYSTAL DISPLAY DEVICE AND FABRICATING METHOD THEREOF AND METHOD OF REPAIRING PIXEL USING THE SAME

【BRIEF DESCRIPTIONS OF THE DRAWINGS】

Fig. 1 is a plan view showing a conventional liquid crystal display device.

Fig. 2 is a plan view showing a conventional liquid crystal display device in which two thin film transistors (TFTs) are formed in a pixel.

Fig. 3 is a plan view showing a liquid crystal display device according to a first embodiment of the present invention.

Fig. 4 is a sectional view showing the liquid crystal display device taken along the line A-A' in Fig. 3.

Fig. 5 is a sectional view showing the liquid crystal display device to be formed after conducting repair by laser.

Figs. 6a to 6e are plan views showing a fabricating method of the liquid crystal display device shown in Fig. 3.

Fig. 7a to 7e are sectional views showing a fabricating method of the liquid crystal display device shown in Fig. 4.

Fig. 8 is a plan view showing a liquid crystal display device according to a second embodiment of the present invention.

Fig. 9 is a sectional view showing the liquid crystal display device taken along the line B-B' in Fig. 8.

Fig. 10 is a sectional view showing the liquid crystal display device to be formed after conducting repair by laser.

Figs. 11a to 11e are plan views showing a fabricating method of the liquid crystal display device shown in Fig. 8.

Figs. 12a to 12e are sectional views showing a fabricating method of the liquid crystal display device shown in Fig. 9.

Fig. 13 is a plan view showing a liquid crystal display device according to a third embodiment of the present invention.

Fig. 14 is a sectional view showing the liquid crystal display device taken along the line C-C' in Fig. 13.

FIG. 15 is a sectional view showing the liquid crystal display device to be formed after conducting repair by laser.

Figs. 16a to 16d are plan views showing a fabricating method of the liquid crystal display device shown in Fig. 13.

Figs. 17a to 17f are sectional views showing a fabricating of the liquid crystal display device shown in Fig. 14.

Fig. 18 is a plan view showing a liquid crystal display device according to a fourth embodiment of the present invention.

Fig. 19 is a sectional view showing the liquid crystal display device taken along the line D-D' in Fig. 18.

Fig. 20 is a sectional view showing the liquid crystal display device to be formed after conducting repair by laser.

Figs. 21a to 21d are plan views showing a fabricating method of the liquid crystal display device shown in Fig. 18.

Figs. 22a to 22d are sectional views showing a fabricating method of the liquid crystal display device shown in Fig. 19.

Detailed descriptions of the reference number

1, 31: transparent substrate
2, 32: gate line
4, 34: data line
6, 36: gate electrode
8, 38: source electrode
10, 40: drain electrode
12, 42: gate insulating film
14, 44: active layer
16, 46: ohmic contact layer
18, 48: protective film
20, 50: contact hole
22, 52: pixel electrode
24, 54: storage electrode
28: source electrode for repair
30, 60: drain electrode for repair
62: photoresist
64: diffraction mask
66: photoresist pattern

[Detailed description of the invention]

[Object of the invention]

[Technical field including the invention and prior art therein]

This invention relates to a liquid crystal display device and fabricating method thereof, and more particularly to a liquid crystal display device and a fabricating method thereof that is capable of increasing an aperture ratio and increasing repair efficiency. Also, this invention relates to a method of repairing a bad pixel by using the liquid crystal display device.

Generally, a liquid crystal display (LCD) device controls a light transmittance using an electric field to display a picture. To this end, the LCD device includes a liquid crystal panel having liquid crystal cells arranged in a matrix type, and a driving circuit for driving the liquid crystal panel. The liquid crystal panel is provided with pixel electrodes for applying an electric field to each liquid crystal cell, and a reference electrode or a common electrode. Typically, the pixel electrode is provided on a lower substrate for each liquid crystal cell, whereas the common electrode is integrally formed on the entire surface of an upper substrate. Each of the pixel electrodes is connected to a thin film transistor (TFT) used as a switching device. The pixel electrode drives the liquid crystal cell, along with the common electrode, in accordance with a data signal to be supplied via the TFT.

Referring to Fig. 1, a lower substrate 1 of a conventional LCD device includes a TFT T arranged at an intersection between a data line 4 and a gate line 2, a pixel electrode 22 connected to a drain electrode 10 of the TFT T, and a storage capacitor S positioned at an overlapping portion between the pixel electrode 22 and the previous gate line 2'.

The TFT T includes a gate electrode 6 protruded from the gate line 2, a source electrode 8 protruded to the data line 4, and the drain electrode 10 connected, via a contact hole 20, to the pixel electrode 22. Further, the TFT T includes a gate insulating film (not shown) for insulating the gate electrode 6 from the source electrode 8 and the drain electrode 10, and semiconductor layers 14 and 16 for defining a channel between

the source electrode 8 and the drain electrode 10 by a gate voltage applied to the gate electrode 6. Such a TFT T responds to a gate signal from the gate line 2 to selectively apply a data signal from the data line 4 to the pixel electrode 22.

The pixel electrode 22 is positioned at a cell area divided by the data line 4 and the gate line 2 and is made from a material such as Indium Tin Oxide (ITO) having a high light transmittance. The pixel electrode 22 is formed on a protective film (not shown) which is coated on the entire surface of the lower substrate 1, and electrically connected with the drain electrode 10 through a contact hole 20 formed in the protective film. The pixel electrode 22 generates a potential difference from a common transparent electrode (not shown) provided at an upper substrate by the data signal to be supplied via the TFT T. By this potential difference, a liquid crystal positioned between the lower substrate 1 and the upper substrate is rotated due to its dielectric anisotropy. Thus, the liquid crystal allows a light inputted, via the pixel electrode 22, from a light source to be transmitted toward the upper substrate.

The storage capacitor S is charged with a voltage in an application period of a gate high voltage to the previous gate line 2' while discharging the charged voltage in an application period of a data signal to the pixel electrode, to thereby prevent a voltage variation in the pixel electrode 22. In this way, because the storage capacitor is used for having the pixel voltage remain stable, its capacitance value should be big enough. To this end, the storage capacitor S is formed in the manner of overlapping with the gate line 2' as having a gate insulating film therebetween.

In this liquid crystal display device, when there is used a normally white twisted nematic (TN) mode type liquid crystal, if a defect occurs at the channel between the source electrode 8 and the drain electrode 10 a problem occurs. The pixel cell is displayed as a brightness point because a voltage is not applied to the pixel electrode 22. Because the bad pixel cell, having

the drain electrode 10 and the source electrode 8 opened, is brightly displayed, an observer of the bad pixel cell will readily notice it. Thus a repair will be needed so that the observer will not perceive the bad pixel cell.

One way to repair the bad pixel cell is to connect a neck part of the channel between the source electrode 8 and the drain electrode 10 by a laser, such that the data signal is always applied from the data line 4 to the pixel electrode 22. As another way, the pixel electrode 22 can be directly connected to the data line 4 by welding the pixel electrode 22 with the laser.

In this case, the neighbor pixel cells of the repaired bad pixel cell realize normal color, whereas the bad pixel cell does not receive the desired data such that it is not possible for the liquid crystal display device to realize the complete color.

In Fig. 2, there is shown a liquid crystal display device disclosed in Japanese Patent Laid-open Gazette No. H02-170614 (publication date: July 12, 1990), which has a main TFT and a repair TFT and the channels of the main TFT and the repair TFT are separately formed.

Referring to Fig. 2, there are a main TFT MT positioned at the area below the pixel electrode 22 and horizontally in the middle of the pixel electrode 22, and a repair TFT RT positioned at the area between the data line 4 and the pixel electrode 22. The main TFT MT includes the source electrode 28 formed to extend in a perpendicular direction to the data line 4 (the gate line 2 direction) and the drain electrode 30 connected with the pixel electrode 22. Also, the repair TFT RT includes the source electrode 8 protruded from the data line 4, and the drain electrode 30 not connected with the pixel electrode 22.

The main TFT MT responds to a gate signal from the gate line 2 to selectively supply a data signal from the data line 4 to the pixel electrode 22. The pixel electrode 22 is positioned at the cell area divided by the data line 4 and the gate line 2,

and generates a potential difference from a common transparent electrode (not shown) formed on an upper substrate by the data signal to be supplied via the main TFT MT. By this potential difference, the liquid crystal located between the lower substrate and the upper substrate rotates due to its dielectric anisotropy, and an incident light from a light source via the pixel electrode 22 is transmitted toward the upper substrate.

If a failure of the main TFT MT occurs, the data signal is not supplied to the pixel electrode 22 from the data line 4 by cutting between the source electrode 8 and the data line 4 of the main TFT MT. Then, the pixel electrode 22 is welded by the laser 50 so as to allow the drain electrode 30 for repair to be connected with the pixel electrode 22. By this arrangement, the data signal from the data line 4 is supplied to the pixel electrode 22 through the repair TFT RT including the source electrode 8 for repair and the drain electrode 10 for repair. As a result, the bad pixel cell realizes the normal color.

Such a TFT repair structure of the liquid crystal display suffers drawbacks.

For example, when repairing the bad pixel cell with a broken wire, the source electrode 28 of the main TFT MT is formed rather long along the gate line 2 from the data line 4. Due to this, a display area decreases. The display area decreases as much as the area where the source electrode 8 is formed of metal, such that an aperture ratio decreases. As a result, it becomes difficult to form the storage capacitor by overlapping the gate line 2 with the pixel electrode 22.

Also, because the data line 4 is formed vertically in a line type, the source electrode of TFT is protruded from the data line 4, and then the source electrode of the main TFT MT and the source electrode 28 of the repair TFT RT are formed at separate areas, this also works as a factor reducing the aperture ratio. That is, because two source electrodes diverging from the data line 4 are necessary in one pixel area and the two

source electrodes need space for themselves, the size of the pixel electrode diminishes relatively.

Moreover, in the TFT RT, as in Fig. 2, when the drain electrode 10 and the pixel electrode 22 are planarly separated, it is difficult to connect the drain electrode 10 and the pixel electrode 22 by the laser in order to repair it. Further, the gate electrode or a semiconductor layer can be damaged during the process.

[Technical subject matter to be solved by the invention]

Therefore, an object of the present invention is to provide a liquid crystal display device and a fabricating method thereof for increasing repair efficiency and an aperture ratio at the same time.

Another object of the present invention is to provide a method of repairing a bad pixel by using the liquid crystal display device.

[Configuration and operation of the invention]

To this end, a liquid crystal display device according to the present invention includes a main thin film transistor having a common source electrode supplied with a data signal, a pixel drain electrode opposed to the common source electrode as having a predetermined main channel between them and connected to a first pixel electrode for driving the liquid crystal of a first horizontal line, and a gate electrode for switching on/off the main channel in response to a scan signal; an auxiliary thin film transistor having the common source electrode and the gate electrode in the main thin film transistor, and a repair drain electrode opposed to the common source electrode as having a predetermined auxiliary channel between them and formed to overlap with a second pixel electrode for driving the liquid crystal of a second horizontal line, wherein active layers forming the main channel and the auxiliary channel are connected to each other in the common source electrode area.

A liquid crystal display device includes a gate insulating film formed to cover the gate electrode and the gate line on a substrate; a semiconductor layer formed on the gate insulating film; a protective film formed on the entire surface of the gate insulating film to cover the common source electrode, the pixel drain electrode and the repair drain electrode; and a contact hole formed in the protective film for electrically connecting the pixel drain electrode with the pixel electrode.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor, the auxiliary thin film transistor and a data line.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor and the auxiliary thin film transistor.

The liquid crystal display device includes a gate insulating film formed to cover the gate electrode and the gate line on a substrate; a semiconductor layer formed on the gate insulating film; a protective film formed on the entire surface of the gate insulating film to cover the common source electrode, the pixel drain electrode and the repair drain electrode; and a contact hole formed in the protective film for electrically connecting the pixel drain electrode to the pixel electrode, wherein the common source electrode, the pixel drain electrode and the repair drain electrode are patterned simultaneously as the semiconductor layer.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor, the auxiliary thin film transistor and a data line.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor and the auxiliary thin film transistor.

A fabricating method of a liquid crystal display device according to the present invention includes the steps of: forming a gate line and a gate electrode on a substrate; forming a gate insulating film on the substrate; forming a semiconductor layer on the gate insulating film; forming a data line and a common source electrode on the gate insulating film, and in addition, forming a pixel drain electrode and a repair drain electrode to oppose the common source electrode such that a main channel of a main thin film transistor and an auxiliary channel of an auxiliary thin film transistor reside in the semiconductor layer together; forming a protective film on the gate insulating film to cover the common source electrode, the pixel drain electrode and the repair drain electrode; and forming a pixel electrode on the protective film to overlap with the repair drain electrode and to be electrically in contact with the pixel drain electrode.

The gate electrodes of the main thin film transistor and the auxiliary thin film transistor are unified at the common source electrode area.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor, the auxiliary thin film transistor and the data line.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor and the auxiliary thin film transistor.

A fabricating method of a liquid crystal display device according to the present invention includes the steps of: forming a gate line and a gate electrode on a substrate; forming a gate insulating film on the substrate to cover the gate electrode and the gate line; forming a semiconductor layer, a common source electrode and a data line by depositing a semiconductor material and a metal layer on the gate insulating film and patterning them together, and in addition, forming a pixel drain electrode and a repair drain electrode to oppose the

common source electrode such that a main channel of a main thin film transistor and an auxiliary channel of an auxiliary thin film transistor reside in the semiconductor layer together; forming a protective film on the gate insulating film to cover the common source electrode, the pixel drain electrode and the repair drain electrode; and forming a pixel electrode on the protective film to overlap with the repair drain electrode and to be electrically in contact with the pixel drain electrode.

The gate electrodes of the main thin film transistor and the auxiliary thin film transistor are unified at the common source electrode area.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor, the auxiliary thin film transistor and the data line.

The semiconductor layer is formed at the peripheral areas of the main thin film transistor and the auxiliary thin film transistor.

A repairing method of a liquid crystal display device according to the present invention includes the steps of: connecting a pixel drain electrode for driving to a pixel electrode of a first horizontal line, and in addition, providing a thin film transistor including a repair drain electrode that overlaps with a pixel electrode of a second horizontal line; sensing a bad pixel included in the horizontal lines; opening a part of a drain electrode for driving of the bad pixel; and connecting the repair drain electrode to the pixel electrode of the bad pixel such that the same color data as a normal pixel, is supplied to the pixel electrode of the bad pixel.

These and other objects and features of the invention will be apparent from the following detailed description of the embodiments of the present invention with reference to the accompanying drawings.

With reference to Figs. 3 to 22d, the preferred embodiments of the present invention will be described.

Referring to Figs. 3 and 4, in a liquid crystal display device according to a first embodiment of the present invention, a lower substrate 31 includes a dual channel TFT DT positioned at the intersection a data line 34 and a gate line 32. The dual channel TFT DT has one common source electrode 38 being connected with the data line 34, and has a structure that a pixel drain electrode 40 and a repair drain electrode 60 are formed at the neighboring part of the common source electrode 38 and, between the pixel drain electrode 40 and the common source electrode 38 and between the repair drain electrode 60 and the common source electrode 38, each channel is formed. In the TFT of the liquid crystal display device, when positive data are inputted, an electric current flows from the data line 34 to the pixel electrode 52, and, when negative data are inputted, the electric current flows from a pixel to the data line 34, therefore a source terminal and a drain terminal are changed in accordance with the type of the input data. However, in the present invention, among two terminals of the TFT except a gate terminal, the electrode connected to the data line 34 are referred to as a source electrode 38 and the electrode connected to the pixel electrode 52 are referred to as a pixel drain electrode 40, for the sake of convenience.

The dual channel TFT DT includes a gate electrode 36 protruded from the gate line 32, the common source electrode 38 protruded from the data line 34 and the pixel drain electrode 40 connected to the pixel electrode 52 via a first contact hole 50a in a protective film 48. The dual channel TFT DT further includes a gate insulating film 42 for insulating the common source electrode 38, the pixel drain electrode 40 and the repair drain electrode 60 from the gate electrode 36, and a semiconductor layer 44 for forming a channel between the common source electrode 38 and the pixel drain electrode 40 by a gate voltage supplied to the gate electrode 36. The dual channel TFT DT selectively supplies the data signal from the data line 34 to

the pixel electrode 52 in response to the gate signal from the gate line 32.

The pixel electrode 52 is positioned at the cell area divided by the data line 34 and the gate line 32, and is made of a material such as Indium Tin Oxide (ITO) having a high light transmittance. The pixel electrode 52 is formed on the protective film 48 which is coated on the entire surface of the lower substrate 31, and is electrically connected with the pixel drain electrode 40 via the first contact hole 50a formed in the protective film 48. The pixel electrode 52 generates a potential difference from a common transparent electrode (not shown) formed on the upper substrate, by the data signal supplied via the dual channel TFT DT. By such a potential difference, liquid crystal positioned between the lower substrate 31 and the upper substrate rotates by the dielectric anisotropy, and a light incident from a light source via the pixel electrode 52 is transmitted toward the upper substrate.

A storage capacitor S formed at the overlapping part of the pixel electrode 52 and a previous gate line 32 is charged with a voltage during an application period of a gate high voltage to the previous gate line 32. The storage capacitor S sustains the charged voltage until data of the next frame is inputted so as to play a role in preventing a voltage variation of the pixel electrode 52. In this way, the capacitance value of the storage capacitor S should be large so that a pixel voltage remains stable. To this end, the storage capacitor S is formed with the previous gate line 32 and a storage electrode 54 which is formed as overlapping with the gate line 32 and having a gate insulating film 42 in between them. The storage electrode 54 is electrically connected with the pixel electrode 52 via a second contact hole 50b formed in the protective film 48. The capacitance value of the storage capacitor can be increased by shortening the distance between two electric conductors. The storage electrode 54 is formed between the gate insulating film 42 and the protective film 48 when forming the data line 34, the source electrode 38 and the pixel drain electrode 40. In the

structure that the previous gate line is a terminal of the storage capacitor S, it is important to increase the overlapping area of the pixel electrode 52 and the previous gate line. When one pixel needs the repair TFT, enough area for forming the storage capacitor can be obtained by adopting the dual channel TFT DT as in the embodiment.

The common source electrode 38 wraps around the pixel drain electrode 38 to form a channel having a \`U\` shape. This is to make the flow of an electric current better by widening the width of the channel.

The repair drain electrode 60 is formed to face with the lower part of the common source electrode 38 as having an auxiliary channel in between them. The repair drain electrode 60 is formed on the semiconductor layer 44 to overlap with the pixel electrode. The repair drain electrode 60 does not work when a pixel cell is functioning normally. The repair drain electrode 60 is put to work by being connected with the pixel electrode with laser only when the pixel cell goes bad.

If a broken wire occurs in the channel of the dual channel TFT DT, the neck part of the channel of the dual channel TFT DT is cut by using the laser, such that the data signal from the data line 34 is no longer supplied to the pixel electrode 52. When melting the neck part by the laser, the overlapping part of the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT, the protective film 48 between two electrodes is molten simultaneously to expose the repair drain electrode 60. The molten pixel electrode 52 flows into the lower part, so that the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT are electrically connected, as shown in Fig. 5. Due to this, the data signal inputted to the previous pixel electrode is supplied to the pixel electrode 52 upon the high pulse application of the previous gate line, such that the bad pixel cell realizes the same color as the previous one. Generally, since the data size of an adjacent pixel is similar, the bad pixel is not very

perceivable though the data of the previous pixel is inputted. In this case, it is possible to form only one common source electrode 38 as a source electrode while having a structure practically capable of playing a role of two TFT. Then, the area occupied by the source electrode can be reduced to thereby increase the proportion of a display area, e.g., to increase an aperture ratio of the display.

A fabricating method of the liquid crystal display device shown in Fig. 3 will be described with reference to Figs. 6a to 7e.

Referring to Figs. 6a and 7a, a gate line 32 and a gate electrode 36 are formed on a lower substrate 31.

The gate electrode 36 and the gate line 32 are formed by depositing aluminum (Al), copper (Cu) and the like using a sputtering technique or other techniques, and patterning it with a first mask.

Referring to Figs. 6b and 7b, an active layer 44 and an ohmic contact layer 46 are formed on a gate insulating film 42.

The gate insulating film 42 is formed by depositing an insulating material to cover the gate electrode with a plasma enhanced chemical vapor deposition (PECVD) technique. The active layer 44 and the ohmic contact layer 46 are formed by depositing semiconductor materials on the gate insulating film 42 and then patterning them with a second mask.

The gate insulating film 42 is formed with an insulating material such as silicon nitride (SiNx), silicon oxide (SiOx) and the like. The active layer 44 is formed with an amorphous silicon not doped with impurities. Also, the ohmic contact layer 46 is formed with an amorphous silicon highly-doped with impurities.

Referring to Figs. 6c and 7c, a data line 34, a storage

electrode 54, a common source electrode 38, a pixel drain electrode 40 and a repair drain electrode 60 are formed on the gate insulating film 42.

The data line 34, the storage electrode 54, the common source electrode 38, the pixel drain electrode 40 and the repair drain electrode 60 are formed by entirely depositing a metal layer by the CVD technique or the sputtering technique and then patterning it with a third mask. To prevent or reduce failures of a pixel electrode 52, caused by a profile difference at the edge of the electrode, a projected part L of a comb-shape is formed at the edge of the pixel drain electrode 40 and the storage electrode 54. Thereafter, the corresponding part of the ohmic contact layer 46 to the gate electrode 36 is patterned to expose the active layer 44. That is, a channel is formed by eliminating the active layer 44 of the space between the common source electrode 38 and the pixel drain electrode 40 and the space between the common source electrode 38 and the repair drain electrode 60. The corresponding part of the active layer 44 to the gate electrode 36 between the common source electrode 38 and the pixel drain electrode 40 becomes the channel. And the corresponding part of the active layer 44 to the gate line 32 between the common source electrode 38 and the repair drain electrode 60 becomes an auxiliary channel. Accordingly, there are formed a main TFT having the common source electrode 38 as a source terminal and a pixel drain electrode 40 as a drain terminal, and an auxiliary (repair) TFT having the common source electrode 38 as a source terminal and the repair drain electrode 60 as a drain terminal. The common source electrode 38 works as a source terminal of the main TFT and the repair TFT is used commonly. The amorphous silicon of the active layer 44 and the gate terminals of the two TFT are formed to be connected with each other through the lower part of the common source electrode 38, thereby reducing the size of the area occupied by the dual channel TFT DT. The gate electrode 36 protruded only once from the gate line 32' plays a role as a gate for two TFT.

The data line 4, the storage electrode 54, the common

source electrode 38, the pixel drain electrode 40 and the repair drain electrode 60 are formed of chromium (Cr), molybdenum (Mo) and the like.

Referring to Figs. 6d and 7d, a protective film 48 is formed to cover a channel region, the pixel drain electrode 40, the repair drain electrode 60, the common source electrode 38 and the exposed gate insulating film 42, and first and second contact holes 50a and 50b are formed in the protective film on the pixel drain electrode 40 and the storage electrode 54.

The first and second contact holes 50a and 50b are formed by patterning with a fourth mask.

The protective film 48 is formed with an inorganic insulating material such as silicon nitride, silicon oxide and the like, or an organic insulating material having a low dielectric constant such as acrylic organic compound, Teflon, benzocyclobutene BCB, cytop, perfluorocyclobutane and the like.

Referring to Figs. 6e and 7e, the pixel electrodes 52 is formed on the protective film 48.

The pixel electrode 52 is formed by depositing a transparent conductive material such as ITO, Indium Zinc Oxide (IZO) and Indium Tin Zinc Oxide (ITZO) on the protective film 48, and patterning it with a fifth mask. The pixel electrode 52 is electrically in contact with the pixel drain electrode 40 via the first contact hole 50a and with the storage electrode 54 via the second contact hole 50b.

Referring to Figs. 8 and 9, in a liquid crystal display device according to a second embodiment of the present invention, a lower substrate 31 includes the same structural elements as in the liquid crystal display device shown in Fig. 3, except that an active layer, being a semiconductor layer of the dual channel TFT DT, is formed only on the dual channel TFT DT.

As described above, the dual channel TFT DT has one common source electrode 38 being connected with the data line 34. A pixel drain electrode 40 and a repair drain electrode 60 are formed at the peripheral part of the common source electrode 38. In the dual channel TFT DT, a main TFT MT and a repair TFT RT have channel and auxiliary channel between the pixel drain electrode 40 and the common source electrode 38 and between the repair drain electrode 60 and the common source electrode 38, respectively.

In the main TFT MT, a channel is formed at the corresponding part of the active layer 44 to the gate electrode 36 between the common source electrode 38 and the pixel drain electrode 40. And the main TFT MT has the common source electrode 38 as a source terminal and the pixel drain electrode 40 as a drain terminal.

In the repair TFT RT, an auxiliary channel is formed at the corresponding part of the active layer 44 to the gate line 32 between the common source electrode 38 and the repair drain electrode 60. The repair TFT RT has the common source electrode 38 as a source terminal and the repair drain electrode 60 as a drain terminal. The repair drain electrode 60 is formed as overlapping with the pixel electrode 52.

The source terminal of the main TFT MT and the repair TFT RT are used as common source electrodes 38. The active layer 44 and the gate terminals 32 and 36 of the TFT MT and TFT RT are formed to be connected with each other through the lower part of the common source electrode 38. This reduces the size of the area occupied by the dual channel TFT DT. The gate electrode 36 protruded only once from the gate line 32 can play a role of the gate of the dual channel TFT DT.

If a broken wire fault occurs in the channel of the dual channel TFT DT, the neck part of the channel of the dual channel TFT DT is cut using the laser. As a result, the data signal from the data line 34 is no longer supplied to the pixel electrode 52.

Next, the laser is used to melt the overlapping part of the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT, the protective film 48 between the pixel drain electrode 52 and the repair drain electrode 60 is molten simultaneously to expose the repair drain electrode 60. The molten pixel electrode 52 flows into the lower part, such that the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT are electrically connected, as shown in Fig. 10. Due to this, the data signal inputted to the previous pixel electrode 52 is supplied to the pixel electrode 52 upon the high pulse application of the previous gate line 32, such that the bad pixel cell realizes the same color as the previous one. Generally, since the data sizes of adjacent pixels are similar, the bad pixel is not perceivable by inputting the data of the previous pixel. In this case, it is possible to form only one common source electrode 38, and then the common source electrode is practically capable of playing a role with two TFT's. Therefore, the area occupied by the source electrode can be reduced to increase the proportion of a display area, that is, an aperture ratio.

In a method of fabricating a lower substrate 31 of the liquid crystal display device with such a constitution, a gate metal layer is deposited on the lower substrate 31 and patterned to form a gate line 32 and a gate electrode 36, as shown in Figs. 11 and 12a, and then a gate insulating film 42 is formed on the entire surface of the lower substrate. Then, by forming an amorphous silicon layer on the gate insulating film 42 and patterning it, a semiconductor layer 44 of the TFT T is formed only at the peripheral area of a dual channel TFT DT, as shown in Figs. 11b and 12b. Then, By depositing a metal layer on the gate insulating film 42 and patterning it, a storage electrode 54, a data line 34, a repair drain electrode 60, a common source electrode 38 and a drain electrode 40 are simultaneously formed, as shown in Figs. 11c and 12c. Herein, the repair drain electrode is formed as overlapping with the next pixel electrode. Afterwards, a protective film 48 is entirely coated and then patterned, thereby forming a contact hole as shown in Figs. 11d

and 12d. Then, a pixel electrode 52 is formed, as shown in Figs. 11e and 12e, by depositing a transparent conductive material on the protective film 48 and patterning it.

Referring to Figs. 13 and 14, in a liquid crystal display device according to a third embodiment of the present invention, a lower substrate 31 includes the same structural elements as in the liquid crystal display device shown in Fig. 3, except semiconductor layers 44 and 46 are formed at the same time as a data line 34, a storage electrode 54, a common source electrode 38, a pixel drain electrode 40 and a repair drain electrode.

As described above, the dual channel TFT DT has one common source electrode 38 being connected with the data line 34, and has a structure that a pixel drain electrode 40 and a repair drain electrode 60 are formed at the peripheral part of the common source electrode 38. In the dual channel TFT DT, a main TFT MT and a repair TFT RT have channel and auxiliary channel between the pixel drain electrode 40 and the common source electrode 38 and between the repair drain electrode 60 and the common source electrode 38, respectively.

In the main TFT MT, a channel is formed at the corresponding part of the active layer 44 to the gate electrode 36 between the common source electrode 38 and the pixel drain electrode 40. The main TFT MT has the common source electrode 38, as a source terminal, and the pixel drain electrode 40 as a drain terminal.

In the repair TFT RT, an auxiliary channel is formed at the corresponding part of the active layer 44 to the gate line 32 between the common source electrode 38 and the repair drain electrode 60. The repair TFT RT has the common source electrode 38 as a source terminal, and the repair drain electrode 60 as a drain terminal. The repair drain electrode 60 is formed as overlapping with the pixel electrode 52. The source terminal of the main TFT MT and the repair TFT RT are used as a common source electrode 38. The active layer 44 and the gate terminals

32 and 36 of the TFT MT and TFT RT are formed to be connected with each other through the lower part of the common source electrode 38. This arrangement reduces the size of the area occupied by the dual channel TFT DT. The gate electrode 36 protruded only once from the gate line 32 can play a role of the gate of the dual channel TFT DT.

If a broken wire fault occurs in the channel of the dual channel TFT DT, the neck part of the channel of the dual channel TFT DT is cut using the laser. As a result, the data signal from the data line 34 is no longer supplied to the pixel electrode 52. Next, the laser is used to melt the overlapping part of the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT, the protective film 48 between the pixel drain electrode 52 and the repair drain electrode 60 is molten simultaneously to expose the repair drain electrode 60. The molten pixel electrode 52 flows into the lower part, such that the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT are electrically connected, as shown in Fig. 15. Due to this, the data signal inputted to the previous pixel electrode is supplied to the pixel electrode 52 upon the high pulse application of the previous gate line, such that the bad pixel cell realizes the same color as the previous one. Generally, since the data sizes of adjacent pixels are similar, the bad pixel is not perceivable by inputting the data of the previous pixel. In this case, it is possible to form only one common source electrode 38, and then the common source electrode is practically capable of playing a role with two TFT's. Therefore, the area occupied by the source electrode can be reduced to increase the proportion of a display area, that is, an aperture ratio.

Figs. 16a to 17f are sectional views showing a fabricating method of the liquid crystal display shown in Fig. 13.

Referring to Figs. 16a and 17a, a gate line 32 and a gate electrode 36 are formed on a substrate 31.

The gate electrode 36 and the gate line 32 are formed by depositing aluminum (Al), copper (Cu) and the like using a sputtering technique or similar technique, and then patterning it with a first mask.

Referring to Fig. 17b, a photoresist 62 is formed on a gate insulating film 42. Then, on the upper portion of the photoresist is provided with a diffraction mask 64, as a second mask, having a transmission part 64a, a masking part 64b and a diffraction part 64c.

The gate insulating film 42 is formed by entirely depositing an insulating material using the plasma enhanced chemical vapor deposition (PECVD) technique to cover the gate electrode 36. The photoresist 62 is formed by entirely depositing semiconductor layers 44 and 46 and a metal layer 39 on the gate insulating film 42. The gate insulating film 42 is formed with an insulating material such as silicon nitride SiNx, silicon oxide SiOx and the like. The semiconductor layers 44 and 46 are formed with amorphous silicon not doped with impurities and amorphous silicon highly-doped with N-type or P-type impurities. Also, the metal layer 39 is formed with material such as chromium (Cr), molybdenum (Mo) and the like.

The masking part 64b of the diffraction mask 64 is positioned at the area where the repair drain electrode 60, the source electrode 38 and the drain electrode 40 are to be formed, the diffraction part 64c is positioned at the area where a channel is to be formed between the source electrode 38 and the drain electrode 40, and the transmission part 64a is positioned at remaining area.

The diffraction mask 64 selectively irradiates an ultraviolet ray to and exposes the photoresist 62.

Referring to Fig. 17c, a photoresist pattern 66 is formed in the gate insulating film 42.

The photoresist pattern 66 is formed by developing the photoresist 62 with a developing solution such as an aqueous solution. The photoresist pattern 66 of the initially coated thickness is formed at the corresponding area to the masking part 64b. The photoresist pattern 66 of approximate 10~50% of the initially coated thickness is formed at the corresponding area to the diffraction part 64c. The photoresist pattern is eliminated at the corresponding area to the transmission part 64a to expose the lower substrate 31.

Referring to Figs. 16b and 17d, the active layer 44, the ohmic contact layer 44, the repair drain electrode 60, the common source electrode 38 and the pixel drain electrode 40 are formed on the gate insulating film 42.

A projected part L having a comb-shape is formed at the edge of the pixel drain electrode 40 and the storage electrode 54. The comb-shape profile is to prevent failure of a pixel electrode 52 due to a profile at the edge of the electrode.

The active layer 44, the ohmic contact layer 46, the storage electrode 54, the repair drain electrode 60, the common source electrode 38 and the pixel drain electrode 40 are formed by exposing the lower substrate 31, on which the photoresist pattern 66 is formed, to an etchant and by simultaneously etching the metal layer 39 and the semiconductor layers 44 and 46.

The photoresist pattern 66 is eliminated after forming the active layer 44, the ohmic contact layer 46, the repair drain electrode 60, the common source electrode 38 and the drain electrode 40.

Referring to Figs. 16c and 17e, a protective film 48, a first contact hole 50a and a second contact hole 50b are formed on the gate insulating film 42.

The protective film 48, the first contact hole 50a and the second contact hole 50b are formed by depositing an insulating

material on the gate insulating film 42 to cover the repair drain electrode 60, the common source electrode 38 and the pixel drain electrode 40, and patterning it with a third mask.

The protective film 48 is formed with an inorganic insulating material such as silicon nitride, silicon oxide and the like or an organic insulating material having a low dielectric constant such as acrylic organic compound, Teflon, benzocyclobutene (BCB), cytop, perfluorocyclobutane and the like.

Referring to Figs. 6d and 7f, the pixel electrode 52 is formed on the protective film 48.

The pixel electrode 52 is formed by depositing a transparent conductive material such as ITO, IZO and ITZO, and patterning it with a fourth mask. The pixel electrode 52 is electrically in contact with the drain electrode 40 via the first contact hole 50a.

Referring to Figs. 18 and 19, a liquid crystal display device according to a fourth embodiment of the present invention includes the same structural elements as the liquid crystal display device shown in Fig. 8, except that the semiconductor layer are formed simultaneously with the metal layer.

As described above, the dual channel TFT DT has one common source electrode 38 being connected with the data line 34, and has a structure that the pixel drain electrode 40 and the repair drain electrode 60 are formed at the peripheral part of the common source electrode 38. In the dual channel TFT DT, a main TFT MT and a repair TFT RT have channel and auxiliary channel between the pixel drain electrode 40 and the common source electrode 38, and between the repair drain electrode 60 and the common source electrode 38, respectively.

In the main TFT MT, a channel is formed at the corresponding part of the active layer 44 to the gate electrode 36 between the common source electrode 38 and the pixel drain

electrode 40. The main TFT MT has the common source electrode 38 as a source terminal and the pixel drain electrode 40 as a drain terminal.

In the repair TFT RT, an auxiliary channel is formed at the corresponding part of the active layer 44 to the gate line 32 between the common source electrode 38 and the repair drain electrode 60. The repair TFT RT has the common source electrode 38 as a source terminal and the repair drain electrode 60 as a drain terminal. The repair drain electrode 60 is formed as overlapping with the pixel electrode 52. The source terminal of the main TFT MT and the repair TFT RT are used as a common source electrode 38. The active layer 44 and the gate terminals 32 and 36 of the TFT MT and TFT RT are formed to be connected with each other through the lower part of the common source electrode 38. This arrangement reduces the size of the area occupied by the dual channel TFT DT. The gate electrode 36 protruded only once from the gate line 32 can play a role of the gate of the dual channel TFT DT.

If a broken wire fault occurs in the channel of the dual channel TFT DT, the neck part of the channel of the dual channel TFT DT is cut using the laser. As a result, the data signal from the data line 34 is no longer supplied to the pixel electrode 52. Next, the laser is used to melt the overlapping part of the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT, the protective film 48 between the pixel drain electrode 52 and the repair drain electrode 60 is molten simultaneously to expose the repair drain electrode 60. The molten pixel electrode 52 flows into the lower part, such that the pixel electrode 52 and the repair drain electrode 60 of the previous dual channel TFT DT are electrically connected, as shown in Fig. 20. Due to this, the data signal inputted to the previous pixel electrode is supplied to the pixel electrode 52 upon the high pulse application of the previous gate line, such that the bad pixel cell realizes the same color as the previous one. Generally, since the data sizes of adjacent pixels are similar, the bad pixel is not perceivable by inputting the data

of the previous pixel. In this case, it is possible to form only one common source electrode 38, and then the common source electrode is practically capable of playing a role with two TFT's. Therefore, the area occupied by the source electrode can be reduced to increase the proportion of a display area, that is, an aperture ratio.

In a fabricating method of a lower substrate of the liquid crystal display device with such a constitution, the gate metal layer is deposited on the lower substrate 31 and patterned to form the gate line 32 and the gate electrode 36, as shown in Figs. 21a and 22a, and then the gate insulating film 42 is entirely coated on the lower substrate. The active layer 44, the ohmic contact layer 46, the data line 32, the common source electrode 38, the drain electrode 40 and the repair drain electrode 60 are formed simultaneously, as shown in Figs. 21b and 22b, by depositing the amorphous silicon layer and the metal layer on the gate insulating film 42, and then patterning them using the diffraction mask. Subsequently, the first and second contact holes 50a and 50b are formed, as shown in Figs. 21c and 22c, by entirely coating the protective film 48 and patterning it. The pixel electrode 52 is formed, as shown in Figs. 21d and 22d, by depositing a transparent conductive material on the protective film 48 and patterning it.

[Effect of the invention]

A liquid crystal display device and a fabricating method according to the present invention discloses cutting a channel with a laser prevent a data signal from the data line from being applied to the TFT if a fault occurs at the channel and connecting the repair drain electrode of the previous TFT and the pixel electrode. Accordingly, in the present invention, a same color is realized in the faulty or bad pixel cell as the previous pixel cell, contrary to the conventional dark point repair technique, and thereby removing the fault due to the brightness point and increasing the repair efficiency. Also, the liquid crystal display device and the fabricating method thereof

according to the present invention can form commonly the source electrode of the repair TFT to be used when repairing and the source electrode of the main TFT, such that the display area is increased as much as the area of the conventional repair source electrode, and so a high aperture ratio can be realized. Further, since the active layer and the gate electrode of the main TFT and the repair TFT are connected with one another via the lower part of the common source electrode, the pattern is not complicated and the size of the occupied area can be reduced. The pixel repair method using the liquid crystal display device according to the present invention is capable of reducing the difference of brightness and color expression between a bad pixel and other normal pixels when compared to the conventional repair method of making the bad pixel a dark point.

It should be understood to the ordinary skilled person in the art that the invention is not limited to the disclosed embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.